Acid – Base Titration

A titration is a technique used to determine the concentration of substances in a solution. A known volume of the sample to be analyzed is put in an Erlenmeyer flask. The solution in the buret (**titrant**) is added, drop by drop, to the sample until the reaction is complete. To help us identify this point, we choose an indicator that changes colour when the reaction is complete (most common is phenolphthalein). The point at which the indicator changes colour is called the **endpoint** (titrant and sample have completely reacted).
To obtain precise and reliable results, you must know the concentration of one of the reactants (use a standard solution).
A titration involves several trials to improve the reliability of the answer. Typically, at least three consistent trials are done and the average of these trials is used.

Titration Requirements:

- ✓ Spontaneous – chemicals react on their own with an addition of energy
- ✓ Fast – chemicals react instantaneously when mixed
- ✓ Quantitative – reaction is more than 99% complete
- ✓ Stoichiometric – there is a single, whole number mole ratio of amounts of reactants and products

Example:

Sample Problem 1

An acid rain sample containing sulfurous acid was analyzed in a laboratory using a titration with a standard solution of sodium hydroxide. Use the evidence given in Table 3 to determine the concentration of the sulfurous acid.

Table 3: Titration of 25.0 mL of $H_2SO_{3(aq)}$ with 0.105 mol/L $NaOH_{(aq)}$

Trial	1	2	3
final buret reading (mL)	11.1	21.7	32.4
initial buret reading (mL)	0.3	11.1	21.7
volume of $NaOH_{(aq)}$ added	10.8	10.6	10.7

10. Solutions of oxalic acid, $H_2C_2O_{4(aq)}$, have many applications. Like $H_2SO_{4(aq)}$, oxalic acid reacts in a 2:1 mole ratio with sodium hydroxide. Complete the **Evidence**, **Analysis**, and **Evaluation** sections of the following investigation report.

Question
What is the concentration of oxalic acid in a rust-removing solution?

Prediction
The oxalic acid solution is labelled as 10% W/V, or 1.11 mol/L.

Experimental Design
The original oxalic acid solution (rust remover) is diluted by a factor of 100, that is, 10.00 mL to 1000 mL. The concentration of dilute oxalic acid solution is determined by titration with a sodium hydroxide solution.

Evidence
(a) Copy and complete **Table 4.**

Table 4: Volume of 0.0161 mol/L Sodium Hydroxide Required to Neutralize 10.00 mL of Diluted Oxalic Acid

Trial	1	2	3	4
Final buret reading (mL)	14.3	27.8	41.1	13.8
Initial buret reading (mL)	0.2	14.3	27.8	0.4
Volume of $NaOH_{(aq)}$ used (mL)				

Analysis
(b) Using the Evidence in **Table 5**, calculate the concentration of oxalic acid in the rust remover.

Evaluation
(c) Evaluate the Prediction: Is the manufacturer's label accurate?

11. Complete the **Evidence** and **Analysis** for the following titration.

Question
What is the molar concentration of the hydrochloric acid in a solution of kettle-scale remover?

Experimental Design
The hydrochloric acid in a solution of kettle-scale remover is titrated with a standardized solution of barium hydroxide. The colour change of bromothymol blue indicator (from blue to green) is the endpoint.

Evidence
(a) Copy and complete **Table 5.**

Table 5: Titration of 10.00-mL Samples of $HCl_{(aq)}$ with 0.974 mol/L $Ba(OH)_{2(aq)}$

Trial	1	2	3	4
final buret reading (mL)	15.6	29.3	43.0	14.8
initial buret reading (mL)	0.6	15.6	29.3	1.2
volume of $Ba(OH)_{2(aq)}$ added (mL)				
colour at endpoint	blue	green	green	green

Analysis
(b) Using the Evidence in **Table 5**, calculate the concentration of the hydrochloric acid in the kettle-scale remover.

12. Samples of sulfuric acid were titrated with 0.484 mol/L sodium hydroxide. The evidence is shown in **Figure 3.** Calculate the concentration of the sulfuric acid solution.